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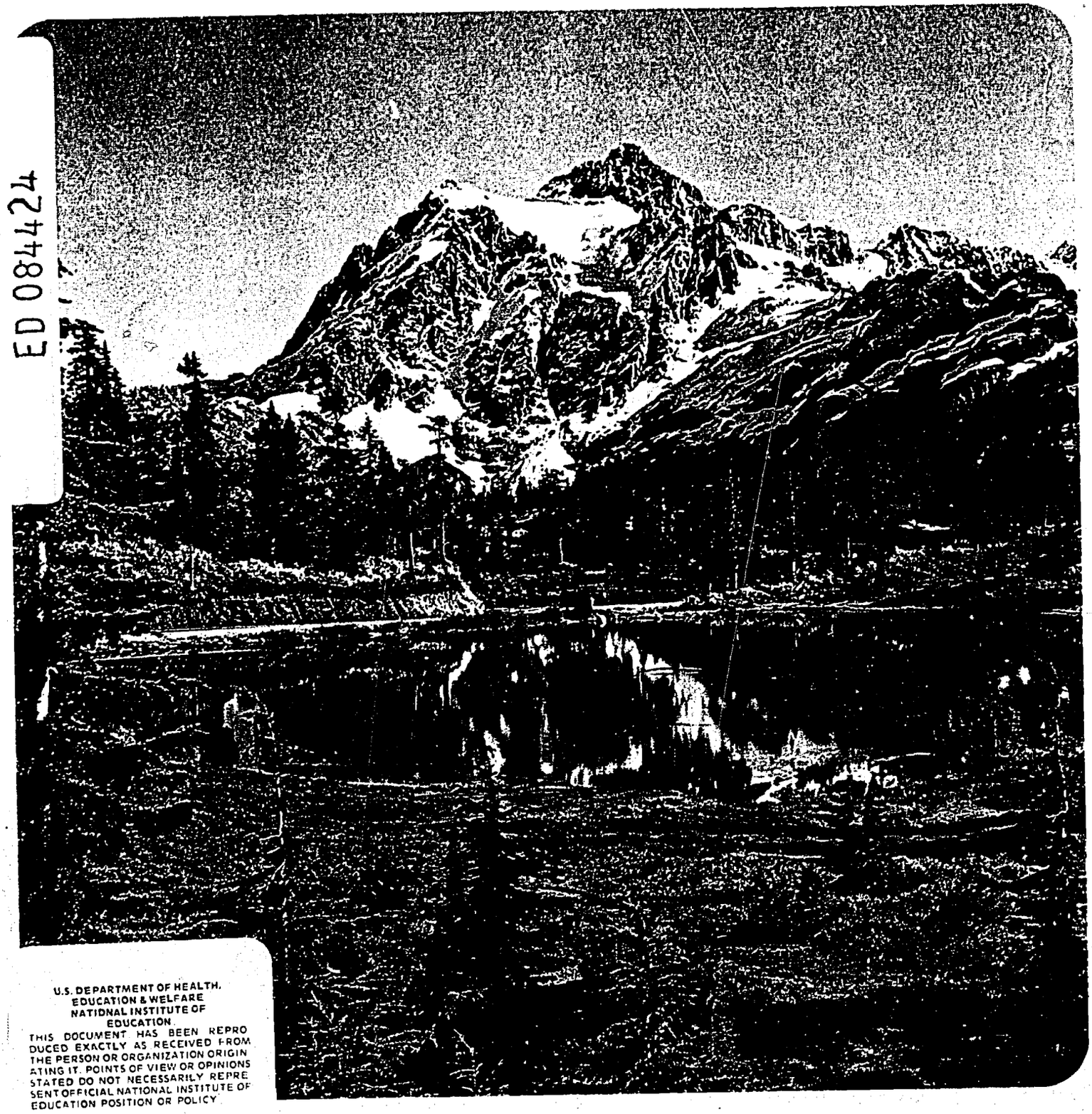
ABSTRACT

Noise is the subject of the student resource unit to be used with high school vocational agriculture students. The nature of noise as a phenomenon and as a problem is clarified. Sources of noise pollution and the decibel levels they produce are described. Among the effects of noise pollution discussed are hearing loss, annoyance, and accidental injury. Control and abatement potentials are suggested. Sections of the document cover current action and future progress. A nine-item bibliography is appended. (MS)



Ag Ed Environmental Education Series

NOISE

WASHINGTON STATE UNIVERSITY IN COOPERATION WITH THE COORDINATING COUNCIL FOR OCCUPATIONAL EDUCATION.

73-3E

PROJECT DIRECTOR

Jay Wood,
Program Director Vocational Agriculture
Coordinating Council for Occupational Education

PROJECT RESEARCHER AND WRITER

Rodney Tulloch,
Curriculum Specialist
Washington State University

PROJECT PRINTING COORDINATOR

Steve Bishopp,
Supervisor, Professional Services
Coordinating Council for Occupational Education

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Environmental Education Series

- Air
- Agricultural Chemicals and Radiation
- Animals
- Land Use
- Noise
- Plants
- Understanding the Environment
- Water

NOISE

by

Rodney W. Tulloch
Assistant Professor
Agricultural Education

Washington State University
College of Education
Department of Education
Pullman, Washington 99163

in cooperation with

Coordinating Council for Occupational Education
216 Old Capitol Building
Olympia, Washington 98504

FOREWORD

This publication is the product of a project carried on by the Coordinating Council for Occupational Education and the Department of Education, Washington State University.

The project grew out of a recognition of the need to include as a part of the high school vocational agriculture curriculum information dealing with the environment, particularly as it related to agriculture. The project was preceded by a period of growing concern that a body of factual information and teacher resources needed to be developed in this area.

E. M. Webb, associate professor of agricultural education emeritus, first suggested that steps be taken to make available to teachers of agriculture and their students factual information on the environment and agriculture. It was through the efforts of Jay Wood, program director, agricultural education, Olympia, that a project was prepared and approved beginning in September 1970.

Valuable assistance was given the project by many persons from the following agencies: Washington State University, University of Washington, Western Washington State College, Soil Conservation Service, United States Department of Agriculture, United States Department of the Interior, Washington Parks and Recreation Department, Washington Department of Ecology, Washington Department of Natural Resources, Washington Department of Agriculture, Washington Department of Fisheries, Washington Water Pollution Control Commission, Environmental Protection Agency, and Washington Department of Game. Many other agencies provided information for the project.

Three publications were extremely useful in preparing this unit. They were *Environmental Quality: The First Annual Report of the Council on Environmental Quality*, *Environmental Quality: The Second Annual Report of the Council on Environmental Quality*, and *The Fight for Quiet*. Information from these publications was used as a basis for much of this unit.

Grateful acknowledgment is hereby made to the following groups of people. Dr. C. O. Loreen and Dr. Keith E. Fiscus, both teacher-educators and state supervisors in agricultural education, and Mr. Jay M. Wood, program director, agricultural education, who gave able assistance to this endeavor. Mr. Pat Alleyn, Mr. James Berry, and Mr. Douglas Verschaeve, teachers of agricultural education in Washington high schools, reviewed the unit, developed teaching materials to be used with the unit, and taught the unit to their students. Many other teachers also made valuable contributions to the project.

The following subject-matter specialists reviewed the unit: Dr. James Englund, associate professor, mechanical engineering, Washington State University, and Mr. Duane Robinson, senior development engineer, International Harvester Company, Truck Division.

This unit is one of eight being produced under the project. The other seven include: *Understanding the Environment*, *Water*, *Land Use*, *Agricultural Chemicals and Radiation*, *Animals*, *Plants*, and *Air*.

July 1972

Rodney W. Tulloch

CONTENTS

INTRODUCTION

Noise is a rapidly growing pollution problem. It is especially severe in most urban areas, which include three-quarters of the Nation's population. Nearly endless sources of noise include air and surface transportation, construction projects, and industrial noise. Although actual noise levels have increased, the awareness and irritation to noise have increased even more.

The most severe noise conditions are generally found in particular types of work. In occupations where the workers are exposed to high levels of noise for long periods of time, irreversible hearing losses may result. It is estimated that as many as 16 million American workers may suffer hearing damage. In addition to the exposure while at work, many of these workers must endure high levels of noise while traveling to and from work. Many of these same workers enjoy relatively noisy recreation activities, thus adding to their total exposure to noise. These same persons are also exposed to noises at home such as household appliances, noisy neighbors, and power mowers.

The farmer is not isolated from noise damage. Farm workers on mechanized farms have been shown to be suffering hearing losses. Anyone who has visited a highly mechanized farm recently will recognize some of the noise problems that the farmer faces.

Sound can be transmitted through almost anything. Most sound travels through air. As the source of a sound vibrates it squeezes molecules of air together and then returns to normal. Then it squeezes some more and again returns to normal. These vibrations continue until the compressions and expansions of the air weaken and die away.

Sound passes through air in a manner similar to the way waves of grain move. For example, wheat may alternately bend over and straighten up thus appearing to move (ripple) while the roots are actually stationary. In the same manner, molecules move back and forth under pressure of sound waves, but never move far from their original position.

These waves of sound in the air are called *sound waves.* Sound waves travel about 1100 feet per second or 760 miles per hour in room temperature air at sea level. This is called the *speed of sound.* When something exceeds the speed of sound it is said to "break the sound barrier." When the *sound "barrier"* is broken, air molecules are pushed, rather than vibrated, and travel faster than they normally would. This speeded up push of the air molecules results in *sonic booms.*

The rate at which a sound vibrates determines the *frequency* of the sound. Frequency is expressed as cycles per second (cps) or hertz (Hz). The higher the frequency, the closer the peaks of the sound wave are together. A young person with good hearing can hear frequencies in the range of 15 Hz to 20,000 Hz. Middle C on a musical instrument is 261 Hz.

As a sound becomes louder, the frequency will seem higher. It is important to realize that both loudness and frequency (which together form pitch) may influence our psychological reaction to noise as well as have an effect on hearing. The psychological reaction to noise is very important. Even a soft noise that creates fear is much more annoying than a louder noise that does not. The distant sound of an airplane may be annoying to someone who is afraid of an airplane crashing. On the other hand, driving a noisy tractor may annoy them little if at all.

The size of the "ripple" caused by a sound wave is referred to as sound pressure. Therefore, loud sounds have relatively strong pressures. Sound pressure can be determined quantitatively (quantity or amount can be measured). Because of the extremely large range of sound pressures commonly observed, measurements are expressed as sound pressure

levels. The term "level" implies a logarithmic rather than a linear scale of measurement. This logarithmic scale of sound pressure has been assigned indicators at various levels. These are called decibels (dB).

The human ear, however, does not respond equally to the same sound pressures at different frequencies. Generally, lower frequencies do not sound as loud. Sound pressure level meters have been developed with filtering networks so that the readings on the scale are similar to the average response by a human ear. The scale, when such a filtering network is employed, is called the A-scale, written dB-A. The A-scale is the most commonly used, and illustrations of various decibel levels on the A-scale as compared to intensity in watts per meter squared are shown in table I.

Table I.—Relationship of Watts per Square Meter to Decibels on the A-Scale

Intensity (watts/m^2)	Sound level (dB)
100 000 000	200
10 000 000	190
1 000 000	180
100 000	170
10 000	160
1 000	150
100	140
10	130
1	120
0.1	110
0.01	100
0.001	90
0.000 1	80
0.000 01	70
0.000 001	60
0.000 000 1	50
0.000 000 01	40
0.000 000 001	30
0.000 000 000 1	20
0.000 000 000 01	10
0.000 000 000 001	0

Source: *Environmental Quality: The First Annual Report of the Council on Environmental Quality.*

SOURCES OF NOISE POLLUTION

Noise pollution like many other sources of pollution is not a new phenomenon. Nature has long contributed noises such as volcanoes, thunder, wind, and waves in varying quantities. Two of man's contributions to sound are music and speech. Some persons would not like to have these referred to as noise. Man's ability to create and make things has been a source of noise since early time. The rattling of steel-rimmed wheels on stones or bricks was a source of irritation that was not lessened by the clatter of horses' hooves often accompanying it.

Primitive societies have always been characterized by the predominance of the sounds of nature and a lack of man-made sounds. The beginning of the Iron Age, however, changed

many societies so that they became accustomed to the beating and hammering of metal. The development of gun powder with its resulting explosions introduced the first real danger of damaging hearing. The beginning of the Industrial Revolution paralleled new increases in the intensities of noise. With the introduction of newer and more powerful engines and larger machines, noise levels rose rapidly. Increased railroads and use of steel, along with the invention of the internal combustion engine, each added their own noises to the environment. More recently, the development of the jet engine and the diesel engine combined with larger, faster machines have meant more noise.

Unfortunately, with a few exceptions, noise has been introduced as rapidly as technology. Little scientific study about noise was done until World War II. It has been reported that noise-induced hearing losses are so widespread among men that it is difficult to establish what their normal hearing is. Noise-induced hearing losses may come from many sources. Loud modern music groups are among the sources that can cause irreparable damage. Many factories and vehicle cabs have excessively high noise levels. Another important factor in noise-induced hearing losses is exposure to gunfire.

Table II lists a number of sound sources and the decibel levels that they produce.

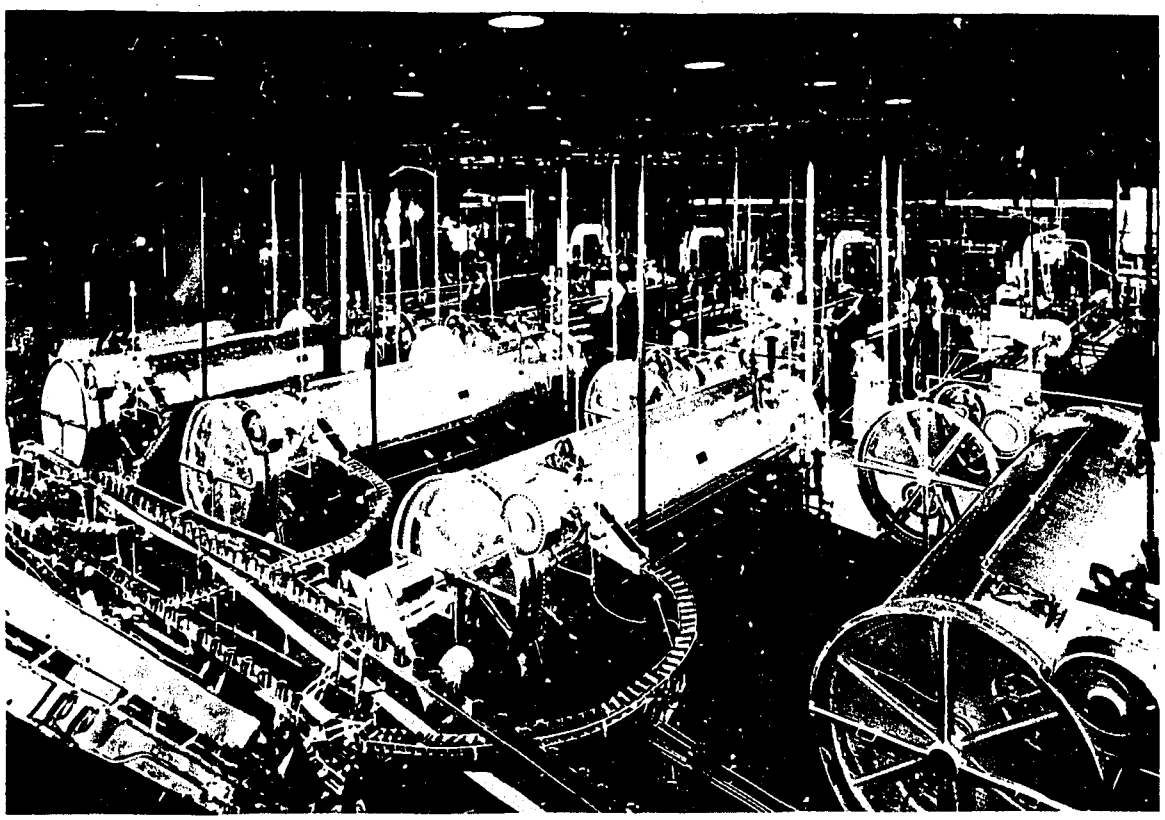
Table II.—Weighted Sound Levels and Human Response

Sound source	dB(A)[a]	Response criteria
	150	
Carrier deck jet operation	140	
		Painfully loud
	130	Limit of amplified speech
Jet takeoff (200 feet)	120	
Discotheque		Maximum vocal effort
Auto horn (3 feet)	110	
Jet takeoff (2000 feet)		
Shout (0.5 feet)	100	
New York subway station		Very annoying
Heavy truck (50 feet)	90	Hearing damage (8 hours)
Pneumatic drill (50 feet)	80	Annoying
Freight train (50 feet)		
Freeway traffic (50 feet)	70	Telephone use difficult
		Intrusive
Air conditioning unit (20 feet)	60	
	50	Quiet
Living room		
Bedroom	40	
Library		
Soft whisper (15 feet)	30	Very quiet
Broadcasting studio	20	
	10	Just audible
	0	Threshold of hearing

Source: *Environmental Quality: The First Annual Report of the Council on Environmental Quality.*

[a]Typical A-weighted sound levels taken with a sound-level meter and expressed as decibels on the scale. The A-scale approximates the frequency response of the human ear.

The heaviest noise pollution takes place in urban areas, the same as with other pollution. Three-quarters of our Nation lives in these urban areas and thus suffers from the effects of noise pollution. Both the awareness of noise and the amount of noise grew significantly during the 1960s in urban areas. People who live in these areas cannot escape noise. They are surrounded with noise while carrying on almost every activity (see fig. 1). Most persons experience the most severe noise conditions while at work. Many work for long periods in conditions that may cause irreversible hearing loss.



USDA Photo

Fig. 1.—Noise is produced by cans of food moving into and out of sterilizers.

Heavy traffic noises may reach 90 decibels. Many persons are subjected to such levels for more than 1 hour per day (see table II). It is generally thought that a steady exposure to about 90 decibels can cause permanent hearing loss. The threshold of pain in hearing is normally reached between 130 and 140 decibels.

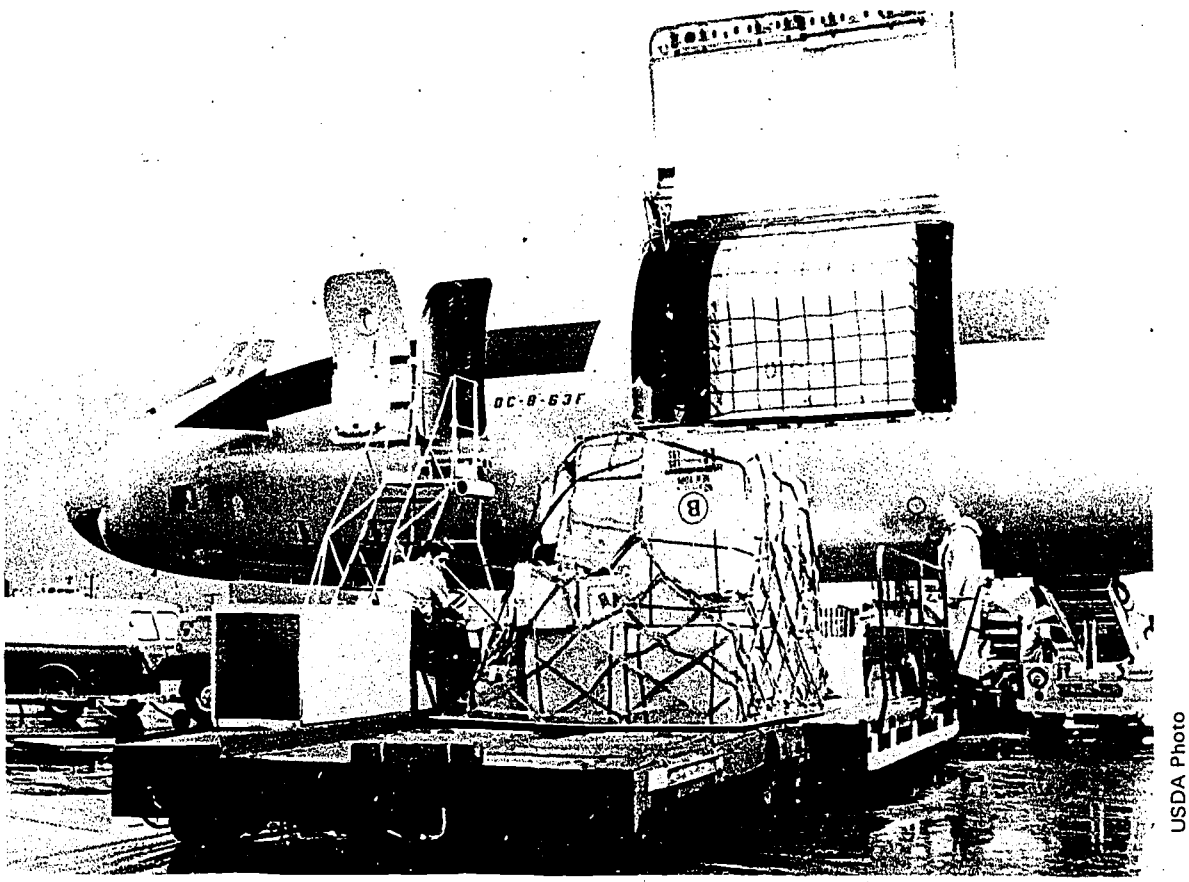
Many of the greatest noise polluters are from the transportation industry. Vehicles such as trucks and buses tend to give off a whir from their tires at high speeds and fairly loud engine noises at slower speeds. A single large truck at expressway speeds can produce more than 90 decibels. A line of trucks can produce noise levels exceeding 100 decibels. Some trucks also have noisy compressors for refrigeration units. Trucks and buses are big noisemakers at highway speeds. Automobile horns are made to give off a sound that will penetrate other noises so that they can be heard. Most automobiles have a pair of horns that, in musical terms, sound a major third. The frequency of each horn is well below the 2000 to 3000 Hz range often found in abundance in urban areas.

Exhausts from motor vehicles may be rather loud. This becomes even more of a problem when exhaust systems become defective or excessively noisy ones are installed. This is especially likely to be true on sports cars and motorcycles. Some vehicle mufflers actually resonate and thereby amplify the noise.

Gears in vehicles may produce a gear whine. Noises may also be produced by bearings, belts, and accessories. The cooling fan and the heating and/or air conditioning circulating fan may also add noise. Brakes may make annoying sounds and squeals. Tires may also make annoying sounds on rapid takeoff, while turning at high speed, and when stopping suddenly. Besides producing a whir or whine at high speeds, tires make a slapping noise on brick roads or pavement joints. The type of tire seems to make little difference in the noise produced. Also, as an automobile increases speed, it has to move more air. This rapid movement of air often causes noises around vehicle windows at higher speeds.

Steel wheels moving on rails give off fairly large amounts of noise. Thus, most rail systems and especially rapid transit rail systems are noisy. Subways may create considerable amounts of noise; although some noise is absorbed by the ground, some escapes and buildings may be vibrated. Sound bouncing off the walls of a subway can raise the noise levels in the cars up to 100 decibels.

Increased use of aviation, including the transportation of agricultural produce, has created a major noise problem in and around airports (see fig. 2). A four-engine jet at takeoff may generate 115 to 120 decibels 250 feet away.



USDA Photo

Fig. 2.—Grapes for the New York market are loaded by forklift near Thermal, California. Noise from this plane will be heard in many rural communities on one trip across the country.

The first scheduled American commercial jet flight was made by a Boeing 707 on October 26, 1958. Jets have the disadvantage of concentrating their noise in certain directions rather than dispersing it in all directions to lessen its intensity. Much research is being done on this problem, and a number of improvements have been made.

The increasing noise due to increasing numbers of airplanes has caused many people, especially those living near airports, to look at air travel with mixed feelings. Many persons will admit that airplanes are a great way to travel but the noise produced by them is very much disliked. In fact, many major airports are receiving increasing numbers of formal complaints concerning noise. They also have been involved in numerous lawsuits regarding noise.

An important decision was made in 1971 by the U.S. Senate and House of Representatives. Further funding of the SST (supersonic transport) was defeated. Although there were many environmental and economic considerations, sonic boom was an important factor in its defeat.

As an airplane exceeds the speed of sound (760 mph), a pressure wave builds up in the air in front of the airplane until it creates an explosive sound called a sonic boom. Sonic booms were considered rather novel when caused by advanced fighter planes after World War II. They were even demonstrated at air shows. However, as they increased in number, they began to be recognized as a serious problem. The sudden loud bang of a sonic boom can be very unnerving. The pressure wave that causes the sonic boom may cover a radius of about 50 miles, so an airplane flying constantly above the speed of sound can leave a 50-mile corridor affected by sonic boom.

Cities suffer from many other sources of noise, most of which are not curbed by Government. Examples of some of these are compressors, jack hammers, riveters, and numerous other pieces of equipment used in building and industry. Garbage trucks, lawnmowers, and noisy vehicles often go unchecked by ordinances. Rock-and-roll music, juke boxes, and motorcycles may add further to the noise problem.

Noise has invaded the home. The kitchen with its numerous appliances is often the noisiest room in the house. This may be especially serious for the housewife who spends much of her day in the kitchen. Gadgets and power tools may also add noise to other parts of the home and contribute greatly to noise outside of the living quarters. Apartments and homes have been built with substandard construction, particularly when it comes to filtering out noise. Many dwellings have been constructed so that outside noise is only very slightly dampened and enters readily. The noise in some areas has become so serious that people have added a low level of constant noise (such as radio) to try to reduce the annoyance from outside noise. Although motor-driven appliances such as garbage disposals, dishwashers, mixers and blenders, forced-air heating systems, vacuum cleaners, refrigerators and freezers, and air conditioners are major contributors, there are many other sources of noise. Nonmotorized noises arise from flushing toilets, showers, stereos, radios, televisions and often, above all, children.

Rural areas have long been considered places where you could retreat from noise. This, unfortunately, has become less and less true as more noises have invaded rural areas. Airplanes fly over rural areas; trucks and trains pass through them. Agricultural equipment continues to receive greater use. Workers on mechanized farms are exposed to various loud and obnoxious noises every day.

Part of what makes the farm worker's plight even greater is the relative lack of protection that he receives from noise pollution. Many industrial workers, such as those working at airports, receive some type of protection from noise pollution.

Health surveys have been made checking the hearing loss among farm people. The results of these surveys have shown that farmers have greater hearing loss than the general public. The amount of hearing loss has been attributed to the amount of time spent on a tractor. Also, the left ear has been found to have more hearing loss than the right ear. This difference in hearing loss between the two ears is attributed to the fact that, as a person operates a tractor, he often turns to the right to observe the operation of the particular implement that he is pulling. This, of course, leaves his left ear closest to the engine and exhaust noises.

Hearing losses tend to increase with age. Hearing losses have also been shown to be worse among farmers who operate larger acreage. This again is attributed to the amount of time spent on noisy machinery.

Since the tractor is the most used noisemaker on the farm, it has received the most study. Research on tractors has been carried on at South Dakota State University investigating some of the noises to which a tractor operator is subjected. The following are some of the things that were found in these studies:

- Noise from the tractor used in the study was sufficient to cause hearing damage after periods of continuous exposure.
- Placing a cab on the tractor considerably increased the noise level at the position of a seated operator's head.
- The noise level in a tractor cab could, however, be effectively reduced by the application of soundproofing material.
- Insulating the tractor did not prove to be an effective method of reducing noise.
- Large-volume mufflers such as the snubber were found to be effective noise suppressors.
- A 2-foot extension added to a factory replacement muffler was effective in reducing noise on the tractor with both the insulated and uninsulated cabs.
- A tractor equipped with a cab and then insulated to the study specifications did meet criteria for acceptable, continuous-exposure operations.

At present, more and more tractors are being made with cabs (see fig. 3). These cabs provide the operator the advantage of certain safety improvements when equipped with roll bars and help cut down his exposure to dust. A cab also protects the operator from external weather conditions. There is considerable doubt if these advantages are worth the possible permanent hearing losses that could result from the higher noise levels in tractor cabs that are not insulated.

EFFECTS OF NOISE

Table II shows in decibels on the A-scale the types of response that the human ear has to noise. Effects of noise may include damage to hearing, disruption of normal activity, and general annoyance. Extremely loud noises, such as explosions or sonic booms, can also cause physical damage to buildings and other structures.

The most common and certainly a very serious effect of noise is hearing loss. Hearing loss may be of either temporary or permanent nature. The amount of permanent hearing loss depends on several factors including the nature of the noise, the time distribution of particular exposures, and the total duration of the exposure over a lifetime, as well as characteristics of the individual. Much noise and hearing loss research has been done on

National Safety Council Photo

Fig. 3.—Cabs do not necessarily decrease the noise the operator receives.

essentially continuous types of noise such as is found in many factories. However, not enough has been done to permit statistical prediction of the risk of hearing damage. The accuracy of these predictions is limited due to the differences in individuals. More research needs to be done, particularly to determine the results of intermittent noise.

Individuals vary considerably in their ability to cope with noise. A very few persons seem able to stand almost any amount of noise without being bothered. On the other hand, some persons are extremely sensitive to noise and are disturbed by almost any kind. Sensitivity to noise may vary considerably from day to day.

Noise has been shown to produce various kinds of temporary changes in man's physiological state. One of these changes is a constriction of the smaller arteries. This in turn may increase pulse and respiration rates. Some medical authorities believe that long-term exposure to loud noises can cause chronic effects. Examples of such chronic effects are hypertension and ulcers. Unexpected noises such as a sonic boom can cause involuntary muscular responses. Prediction and understanding of these involuntary muscular responses will require much more research.

Noise levels now found in parts of some communities exceed standards that have been found injurious in industry. Many medical authorities now believe that hearing losses thought to be due to aging are caused by a lifetime of exposure to noise levels found in many communities. This almost constant noise to which man is being exposed is adversely affecting his ability to hear. Under excellent conditions, a man with good hearing can hear sounds so delicate that they could have been produced by the thermal motion of molecules. At the other extreme man can hear without distortion sounds that contain millions of times more energy.

For a long time, industrial noises have been known to cause hearing losses. For example, persons who worked in such industries as boilermaking and mining and near other continuous sources of noise accepted the loss of hearing as part of the job. In the United

States today, between six and 16 million workers are estimated by the Office of the Surgeon General to be working under conditions that are hazardous to their hearing.

Even when noise does not cause any permanent loss of hearing it may hinder sleep. Noise may also distract from work. Research is needed to determine the effect of noise on performance of manual tasks. Studies so far are somewhat confusing as to the effect of noise on manual tasks. This does not seem so unusual when it is considered that there are many types of tasks that require various amounts of concentration, demand various amounts of quality of workmanship, and require varying repetition rates. Also involved are the types of noise, the intensity and duration of the noise, as well as the personality and mood of the worker and duration of the task. Research to this point shows that the more detailed the work is the more likely the person will be distracted. Another problem is that noise may drown out warning signals and therefore cause accidents or allow a machine to break down unnecessarily. Noise may also cause annoyance and general fatigue. Background music may, however, have advantageous effects.

Several factors may influence the annoyance that accompanies a given noise. These factors include what the noise means to us. For example, if a noise means fear to us it can be extremely annoying. Soldiers in World War II became very irritable upon hearing jet planes that sometimes bombed them. After returning to this country, the sounds of jet planes continued to bother them. In some cases, this annoyance has lasted for many years. The environment in which a noise is heard may also have some important influences. A person is much more psychologically likely to tolerate and accept a given noise if he feels the noise is necessary in producing a useful or valuable service. He is also likely to accept the noise as long as his health is not affected. One survey of noise around an airport has shown that people's general connection between noise and their fear of aircraft crashing has more effect on the degree of annoyance than did the actual amount of noise.

Even with all the factors just mentioned, which may vary with the individual, there are several more factors that can be used to predict how annoying a noise will be. For example, loud noises are more annoying than quieter noises. High-pitched noises above 1500 hertz (cycles per second) are particularly annoying, as are irregular and intermittent noises, noises from hidden sources, and sudden or new noises. Noises that particularly interfere with our activities are more disturbing than the noises we are producing.

Because the higher frequency sounds of speech are those hardest to hear, they are the first to cause hearing loss problems. The first sounds that cannot be heard during hearing loss are f, s, th, ch, sh—all of which are among the higher frequency sounds of speech. This causes people with some hearing loss to feel that they can hear but that they can't understand. Thus, hearing losses of either a temporary or permanent nature can seriously affect the ability of humans to communicate.

Researchers at the University of Tennessee made two important findings about the threat on our hearing by recreational noises. They discovered that the hearing of many high school and university students had already deteriorated to a level of the average 65-year-old person. This study found, as has been found in previous studies, that these students had been exposed not only to loud music but to motorbikes, gunshot noises (see fig. 4), and other loud recreational noises.

Noises have a tendency to work together to cause even more serious problems than would be indicated by exposure to each noise individually. It was also concluded in this study that exposure to such high levels of noise over a considerable period of time may cause severe permanent hearing loss and damage. This loss may be severe enough that it will jeopardize future occupational choices of the person affected. The conclusion is obvious that an ongoing program of safety and education must be started immediately.

Washington State Game Department Photo

Fig. 4.—Exposure to firearm noise can damage hearing.

CONTROL AND ABATEMENT

There are numerous ways to remove noise. They include removing oneself from the scene of the noise, removing the source of the noise, using quieter machines, or dampening the sound.

Removing oneself from the source of the noise is often difficult since various jobs require working under noisy conditions. Many famous persons have been extremely sensitive to noise and some of these have done their best to avoid noise. Several of these persons, when living in hotels, have rented rooms on each side of their own as well as above and below to try to shield themselves from noise. This behavior has often branded these people as fanatics. Some persons have built homes in which they devise rather extreme measures to shield themselves from noise. These measures include the use of insulating materials such as cork, manila rope, and even double doors. Such methods generally cost a considerable amount of money.

A second possibility of getting away from noise pollution is to remove the sources of noise. This procedure has been carried out in countless forms. For example, truck routes have been established away from residential areas; excessively noisy industries and airports

have been located as far as possible from homes. Carrying out these types of noise-reducing activities often requires special zoning. Special rooms have been built in some industries for especially noisy machines.

Another approach used by industry is to replace several smaller machines with one quieter, more efficient machine that will equal the output of the several smaller, noisy machines. This approach is often very expensive. Often things can be done in designing machines to make them less noisy. Machines can sometimes be designed so that men can be further away from them thus reducing the noise problem. One of the major difficulties is that, once a plant has been designed and machinery has been installed, it is extremely difficult to decrease the noise pollution to desirable levels. Therefore, it is obvious that new machines and new plants need to be designed with more consideration for noise pollution abatement to avoid even higher costs at a later time.

A great number of sources of noise can be lessened. Many motorcycles use very poorly designed mufflers or none at all. A good muffler on these motorcycles could go a long way toward protecting the operator's hearing. Agricultural implements and especially tractors could be designed so as to produce less noise. Carefully insulated tractor cabs also reduce noise levels in the vicinity of the operator. Improvements need to be made in farm implement design to help prevent noise pollution. More research needs to be done to find ways of preventing some of this noise.

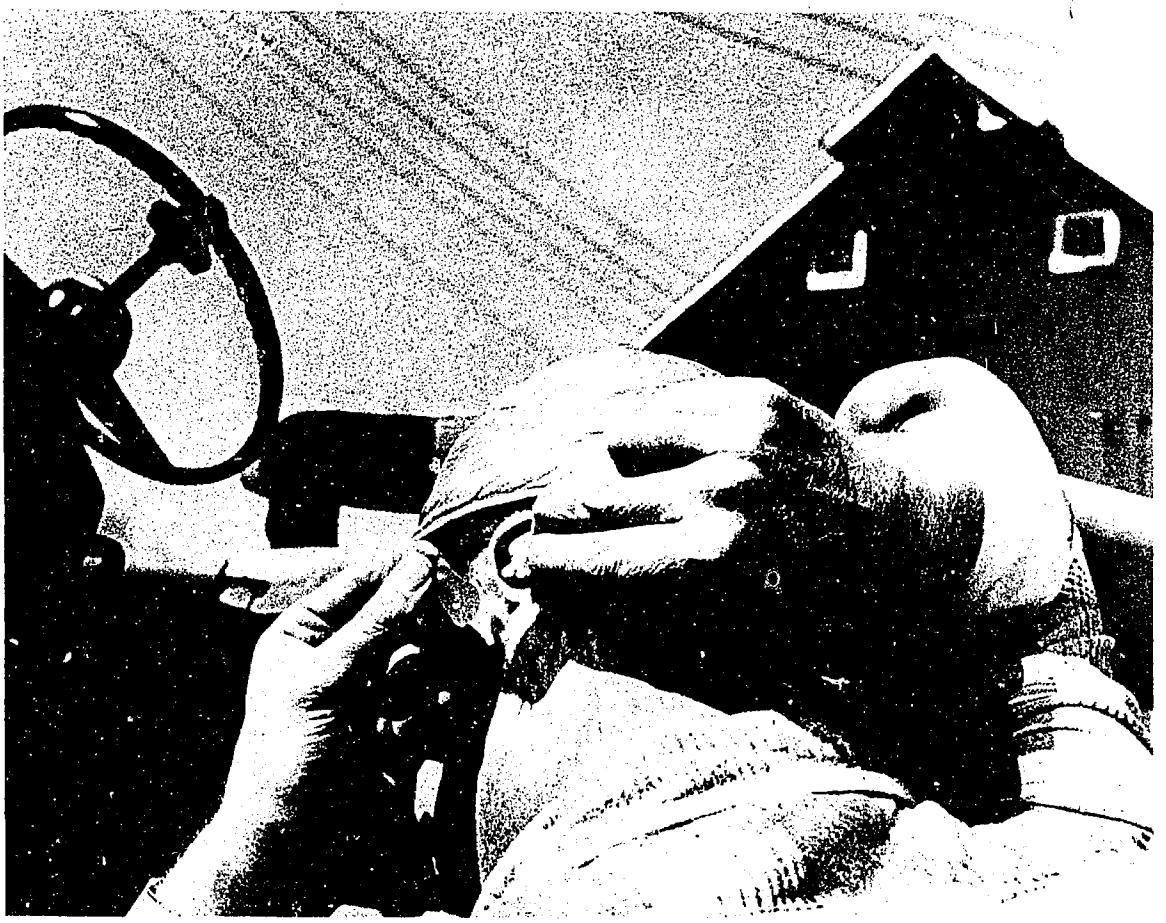
An inexpensive and effective way of cutting noise for the individual is to use earplugs. Although earplugs may be used to effectively cut the amount of noise and therefore the danger of hearing loss, they may also cut out important warning signals. Also, many persons are somewhat reluctant to wear earplugs just as others are reluctant to wear eyeglasses. Several types of earplugs are now available, some of which are for temporary use and some of which are for permanent use. The cost varies considerably with the type of earplug. The fundamental principle is, however, the same—to reduce the loudness of the sound before it reaches the ear drum. Although the principle of all earplugs is the same, there is a considerable difference in the effectiveness between models. The earplug often tends to be uncomfortable and if not properly fitted can allow noise in through leaks. Earplugs must also be kept very clean and shouldn't be used when the ear is infected (see fig. 5).

A number of noise-deafness experts prefer earmuffs. These earmuffs consist of a rigid cup usually filled with some kind of noise-absorbing insulating substance. These fit tightly around the external part of the ear so as to allow no air to enter the ear canal (see fig. 6).

Earmuffs have been shown to be very effective against noise pollution. Unfortunately, they also have disadvantages, including discomfort caused by their large size and tight fit. Because they cut off the air, they often make the ears hot and increase perspiration. Earmuffs are being used by some agricultural equipment operators. It seems relatively certain that more of these will be used by persons in agriculture in the future. Although the dislike for any type of ear protectors seems to be universal, one must consider the hazards to hearing before deciding whether or not to wear such protection.

Many methods have been used to dampen sound. One of the most common is the use of acoustical ceilings. These usually consist of a large number of small holes in a relatively soft material. Sound reflects most off hard flat surfaces. The small holes and soft material act as a poor reflector of sound thus reducing noise. An uneven surface such as the cloth in loosely woven drapes will absorb a considerable amount of sound.

In dampening sound, one of the most important factors is frequency. Low frequencies require very thick materials to show any noticeable abatement. This can be demonstrated by a man talking in a sound-dampened phone booth. His voice will be dampened much less



National Safety Council Photo

Fig. 5.—Custom-fitted soft plastic earplugs give reasonable comfort and effectively seal out harmful noise.

than a woman's high voice. Very high frequencies are also very difficult to dampen. Passage through air stops these best.

One of the problems that we must come to grips with is a decision on how much noise should be allowed. Once this level is set, it must be determined how the noise will be reduced, who will do it, and who should pay for it. Although much research needs to be done to determine the effects of noise more completely, we do not need to wait to begin action. Many persons are now subjected to levels daily that are known to be hazardous to hearing. Working standards can be implemented with the knowledge presently available and changed to meet new research evidence. The amount of control that will be forthcoming will depend to a large extent on the public's desire for noise pollution abatement and their willingness to pay for the action that needs to be taken.

A growing concern for the hazard of noise in our environment has been demonstrated in this country. A small part of this concern has been directed toward reaching solutions to the problem. A very high percentage of the money being spent for noise pollution research is being devoted to aircraft noise and sonic booms. Increased Federal funding, along with funds from other sources, are vitally needed to expand research on abatement of noise from all sources.

National Safety Council Photo

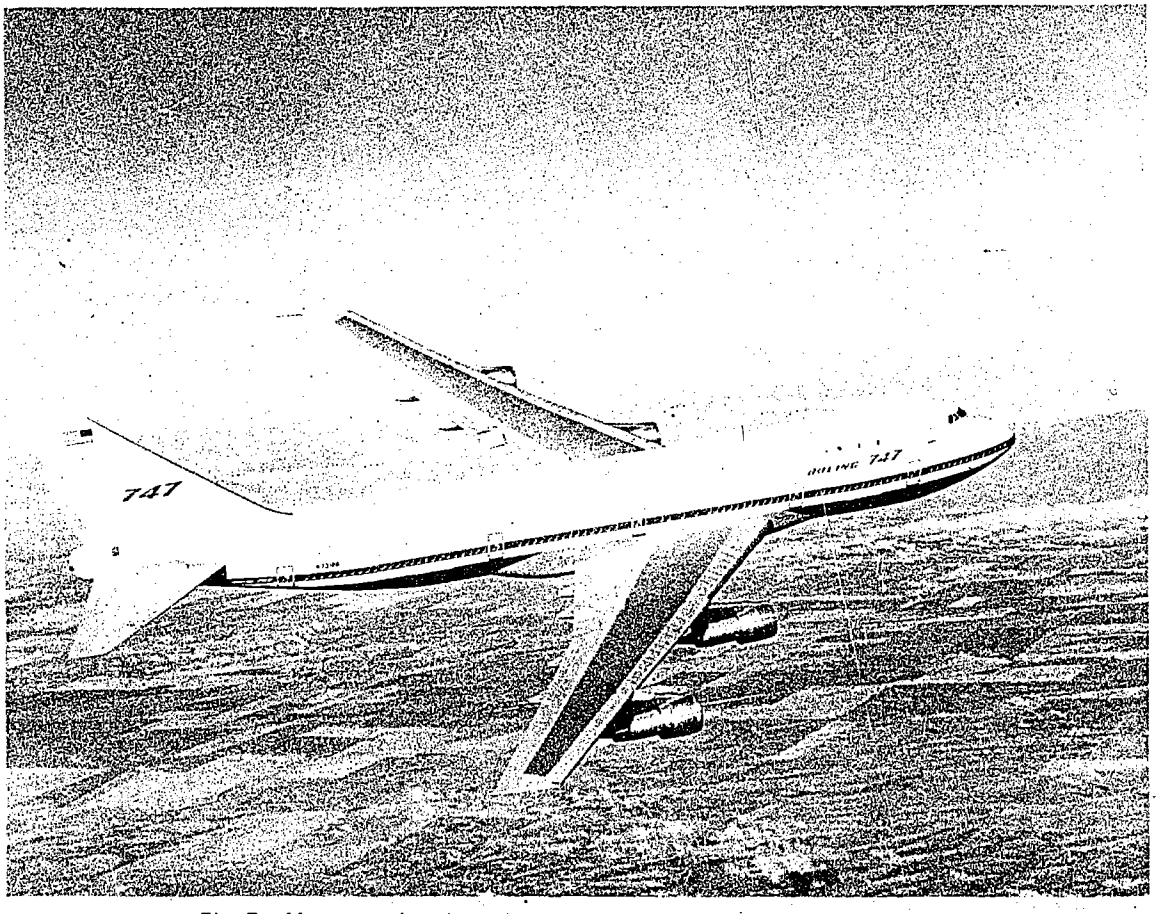
Fig. 6.—Earmuffs can be used to protect the ears in noisy situations.

CURRENT ACTION

Diverse sources of noise pollution are of local significance. These local problems require regulation at the local level. Some problems may exist in localities throughout a State. For this reason, many States have laws relating to muffler noise on motor vehicles. Such laws, unfortunately, are often vague or do not give enforcement techniques or even maximum noise levels. For these reasons, several of the State laws are impossible to enforce.

A number of cities have adopted noise ordinances. Few of these ordinances are strictly enforced. The courts have often rejected efforts by local governments to control noise. For these reasons, State and local noise abatement efforts have had limited effects.

The Federal Government's interest and role in noise pollution has been steadily increasing. Important steps have already been taken. Some of the actions taken by the Federal Government include Federal standards being set for occupational exposure to noise. Noise standards have been set for regulating aircraft noise. Standards for the location of housing sites are being established. New technology is being demonstrated that can cut down noise in jet aircraft (see fig. 7). Research is being continued and extended to help make the United States a quieter nation.



Boeing Company Photo

Fig. 7.—Many new jet planes have been equipped so as to reduce noise.

FUTURE PROGRESS

If present trends continue and Americans continue to demand that everything be larger and faster, noise is likely to continue to increase. This may well mean that we will have to improve our technology just to keep noise at its present level. Quiet costs money. Individuals will have to be willing to pay for noise abatement.

Since the reduction of noise pollution is often expensive, much more legislation will be required to control noise. Loopholes in existing legislation will have to be corrected. Although manufacturers and industries are becoming more aware of noise problems, much remains to be done both in awareness and in design features. Much also remains to be done in the area of informing the public of the noise levels of various items that they intend to purchase. Although some automobiles are now being advertised as being very quiet, more exact specifications need to be given to the consuming public.

The overriding problem in the whole area of noise pollution is the same as in most other areas of pollution—lack of knowledge. Increased education will be the major factor in determining whether noise abatement can be successfully carried out. If people become more aware of the effects of noise pollution, more demands for quiet will be made.

It is expected that future technological breakthroughs will make for quieter operation of some types of machines and equipment. As new buildings are built, they will often have improved acoustical design. The demand for larger and faster transportation facilities will likely offset technological advancements in this area. Other areas may actually increase in noise pollution. Technology is already available to considerably decrease the amount of noise. It is a matter of paying the cost to get the job done.

It is likely that, for increased cost, soundproofing devices will be built into new homes. For example, double-paned windows called thermal panes have been used for some time to help prevent heat loss. In new houses, double-glazed windows developed for acoustical purposes will very likely be used. Specially designed heating and cooling systems also will help cut noise within the house. In addition, walls, ceilings, and possibly even roofs will be lined with materials that will be sound absorbent.

It also seems likely that the internal combustion engine will be replaced by a source of power that will contribute less to noise pollution and reduce other problems as well.

Improvements in noise pollution abatement can be made any time that the general populace is willing to pay for them. How long it will take for us to develop the will to match the way and improve our environment by reducing noise is up to each of us.

SUMMARY

The following recommendations were taken from *Environmental Quality: The First Annual Report of the Council on Environmental Quality:*

1. More research is needed on physiological and psychological effects of noise in order to develop improved remedial programs.
2. Noise standards should be developed for all federally supported or guaranteed construction.
3. A thorough evaluation should be made of the extent of the noise problem, its effects, and the various alternatives open to Federal, State, and local governments, and to industry to reduce noise.

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